Ann. For. Res. 66(2): 199-211, 2023
ISSN: 18448135, 20652445

ANNALS OF FOREST RESEARCH
www.e-afr.org

IMPACT DUE TO MICROPLASTICS POLLUTION IN COASTAL ENVIRONMENT ALONG CHENNAI COAST

Somasundaram Ramesh [1], R. Nagalakshmi [1]
[1]Department of Civil Engineering, SRM Institute of Science andTechnology, Kattankulathur, Chennai, India

Corresponding author: R. Nagalakshmi; Email: nagalakr@srmist.edu.in

Abstract:

The presence of micro plastics in aquatic environments is becoming a growing concern with serious potential impact for both ecosystems and human health. To investigate this problem, we conducted a random sampling to measure the presence and distribution of micro plastics in the coastal waters along Chennai, India. Water and sediment samples are collected from five different locations and also using Fourier transform infrared spectroscopy (FTIR). The results revealed that micro plastics are found in all samples, with the highest concentration in sediment samples. The findings provided evidence of the pervasive nature of micro plastics in the marine water of Chennai, and highlighted the need for management strategies to address the risks micro plastics present to both ecosystems and public health.
Keywords: Microplastics; Aquatic environment; Chennai coast; Pollution; Sustainable practices.

1. Introduction:

Plastic pollution is a major environmental issue that has significant impacts on the health of the ecosystem and human well-being (Khuc et al. 2023)[1]. Micro plastics, measuring less than 5 mm in diameter, are very pervasive in aquatic environments and are a growing problem due to their resistance to degradation (Yingling Deng Jiang Wu and Kang 2023)[2]. They can enter the environment through various sources, including direct discharge of plastic waste, storm water runoff, and industrial effluents (Cho et al. 2023)[3]. India is a major source of plastic waste pollution, with its coastal regions particularly affected (Prabawati et al. 2023)[4], including Chennai, are particularly vulnerable to plastic pollution due to their proximity to major urban centers and industrial areas (Ashokan et al. 2023) [5]. The Chennai coast is an important ecological hotspot that supports diverse marine life and provides a livelihood for many people (Roy et al. 2023) [6]. However, the impact of micro plastics on this important ecosystem remains poorly understood (Sun et al. 2022)[7]. The aim of the research is to determine the prevalence and identification of micro plastics in the aquatic environment along the Chennai coast. Water and sediment samples will be collected from five different locations and analyzed using Fourier transform infrared spectroscopy (FTIR) to identify and quantify plastic particles. The findings of the research could provide valuable insights into the extent and distribution of micro plastics in the Chennai coast and help formulate effective management strategies. Such findings could prove beneficial in formulating policies and regulations to reduce the impacts of micro plastics on aquatic ecosystems and human health.

The article is structured in five sections. Sect. 2 reviews recent literature works. Sect. 3 outlines the proposed methodology. Sect. 4 demonstrates the experimental results and discussions. Sect. 5 summarizes the research and provides direction for future studies.

2. Literature Review:

(Harikrishnan et al. 2023) studied the micro plastic (MP) contamination of different marine fish species, caught along the south coast of India in Chennai coastal area. The findings revealed that 1115 MPs were detected in the fish samples, with 68% being fibres and fragments. (Jessieleena and Nambi 2023)[9] investigated micro plastics in the coastal region of Chennai, India. Both water and sediment samples found both containedmicro plastics, which were mostly fibrous types and accompanied with pollutants. The pollution load index indicated that the catchment was polluted, with micro plastic pollution posing potential risks to the environment and aquatic life. (Silori et al. 2023) found high MP concentrations in coastal sediments and agricultural soil in India, China, and Japan, associated with plastic mulching. The effects of the pollutant in Indian soil were largely unstudied, highlighting the need for more research. (Pradhap et al. 2023)found that Upputhanni Island had the highest number of plastics among the Vembar group mainly polypropylene, polyethylene, polystyrene, and nylon. The study showed low risk for plastic contamination in the reef environment.

(Goswami et al. 2023) found a surface water concentration of 0.013 ± 0.002 particles/m3 in the Arabian Sea basin, composed of polyamide, polyethylene, polypropylene, and PVC; suggesting contamination from textile, fishing, shipping, and packaging industries. The study concluded that more dedicated efforts were required to protect the marine environment from the harmful effects of micro plastics.

(Mikhailenko and Ruban 2023) focused on the ways that heavy metals found in plastics are distributed geographically across different sea beaches. Their study revealed 20 global localities with either potential or current environmental risks from these materials, with the greatest attention given to asian and European countries. The authors also noted a lack of research on the prevalence of Hg-bearing plastics on beaches. For this reason, they called for further research and effective policy measures to tackle the ecological consequences of plastic pollution in marine ecosystems.

(Balachandar et al. 2023) investigated the impact of pollutants on benthic foraminifera as environmental disturbance indicators. Samples taken at five locations along the Chennai coast were analyzed for pollutants, including PAHs, TPH, heavy metals, and TOC.Abnormal species were associated with TPH and PAH concentrations, while pollution-resistant and opportunistic species were identified. Benthic ecosystem response to hydrocarbon pollution along northern Chennai coast was evaluated with environmental health proxies.

(Venkatramanan et al. 2022) discovered high levels of MP accumulation on two Chennai beaches, with 459 (60.8%) and 297 (39.2%) found in chennai coastal region respectively.(Dhineka et al. 2021) analyzed MP levels in near shore sediments along the Chennai to Puducherry coast where levels of MPs found in highest levels near river inlets. The major polymers identified were polyethylene and polypropylene, thus indicating the need for waste management reforms to reduce MP contamination.

(Ranjani et al. 2022) investigated hazard risk from micro plastics in six beaches of Chennai, India. Results showed spatial variation of micro plastics is generally more when compared to south west monsoon season (84-498 items/kg, mean: 302.7 items/kg). SEM images revealed surface weathering and EDS results showed adsorbed metals. Analysis showed hazardous polymers (PVC, PA, PS) posed a high risk despite low contamination. Particle tracking showed 20% settling along the coast, and 80% moving offshore within 30 days, suggesting a how to prevent the entry of plastic debris in marine environment.

3. Study Area

Figure 1, 2 and 3 shows the land cover and land use map in the year 2000,2010 and 2020 respectively. The land area is continuously shrinking because of rapid urbanization and rapid industrialization. Mainly cosmetic related industry simply discharging their untreated effluent in cooum river and severely polluted and micro plastics also entered in coastal belt and because of this aquatic organism affected and water quality also affected.

4. Proposed Methodology:

The proposed method for investigating the load of micro plastics in the aquatic environment along the Chennai coast involves the following steps:

4.1 Sampling:

The sampling process is a critical step to know the prevalence and transport of microplastics in the aquatic environment along the Chennai coast. To ensure the accuracy and reliability of the data, the sampling process will be carefully planned and executed. The sampling locations will be selected based on the proximity to urban areas, industrial zones, and other potential sources of plastic pollution. The five sampling locations will be chosen to represent different parts of the coast, including areas with higher human activity and those with relatively lower human impact. Figure. 4. shows the sample sediments taken from Adyar and Coovum.

During the sampling process, it is important to avoid contamination of the samples by using appropriate equipment and protocols. A grab sampler will be used to collect water and sediment samples from each location. The grab sampler will be thoroughly cleaned and disinfected before use to prevent contamination.

The water samples will be collected at a depth of approximately 10 cm below the water surface to ensure a representative sample. The sediment samples will be collected using a sediment corer, which will be pushed into the sediment to a depth of approximately 10 cm. Both water and sediment samples will be collected in clean glass jars and labeled with the sampling location, date, and time.

After collection, the samples will be transported to the laboratory under controlled conditions, including temperature control, to avoid any alteration of the samples' chemical and biological characteristics. Upon arrival at the laboratory, the samples will be stored in a cold room at a temperature of 4°C until analysis.

This study will assess the prevalence and distribution of microplastics along the Chennai coast. Sampling protocols and equipment will be used to collect water and sediment samples, to better understand microplastic presence in the area.

4.2 Pretreatment:

The pretreatment step is an essential part of the method to ensure the accuracy and reliability of the data. The presence of visible debris, such as leaves, sand, and stones, can interfere with the analysis and make it difficult to identify and quantify microplastics present in the samples.

The pretreatment step will involve several processes to remove any visible debris from the water and sediment samples. Initially, the water samples will be passed through a pre-filter, which will remove larger particles such as leaves, twigs, and other debris. The sediment samples will be left to settle for several hours to allow the larger particles to settle at the bottom of the container.

After pre-filtration or sedimentation, the samples will be decanted into a clean container, and any remaining debris will be removed using forceps or a fine mesh sieve. Care will be taken to avoid any loss of sample during the process.

The pretreated samples will then be ready for microplastic extraction and analysis. It is important to note that the pretreatment process should be conducted with care to avoid introducing any additional contaminants that could interfere with the analysis.

Overall, the pretreatment step is critical to ensure the accuracy and reliability of the data. The optimal removal of visible debris during an analysis of the Chennai coastal environment can minimize interference, enhance microplastics identification / quantification, and reveal prevalence / impact.

4.3Microplastic extraction:

The extraction of microplastics from the water and sediment samples is a crucial step in the method for identifying and quantifying these particles. The filtration method will be used to extract microplastics from the samples, which involves filtering the water and sediment through a filter with a 0.45 µm pore size. Figure. 5 shows microplastic extractor.

The use of a 0.45 µm pore size filter is based on the assumption that microplastics in water and sediment samples are usually smaller than this pore size. The filter will capture micro plastic particles while allowing water and other particles to pass through.

After filtering, the filters will be carefully removed from the filtration apparatus and rinsed with a solvent, such as methanol or ethanol, to remove any remaining organic matter. This step is important because it helps to eliminate potential interference during the analysis and ensures the accuracy and reliability of the data.

The filtered samples will then be analyzed using a microscope or other imaging techniques to detect and analyze the micro plastics present in the samples. The micro plastics will be identified based on their size, shape, color, and other characteristics.

Overall, the filtration method is an effective way to extract micro plastics from water and sediment samples. By carefully executing this step and using appropriate imaging techniques, the study will provide valuable insights into the prevalence and impact of microplastics in the aquatic environment along the Chennai coast.

4.4 Identification of Micro plastics

Fourier Transform Spectroscopy can be used to analyze and identify micro plastic content in water and sediment samples by measuring the absorption of infrared radiation by its molecules to give information about its composition.

In the case of micro plastics, FTIR analysis identifies the specific type of plastic based on its molecular structure. Different types of plastic have unique molecular structures, and FTIR analysis can differentiate between them.

After the filtered samples have been rinsed with a solvent and dried, the FTIR analysis will be conducted. The micro plastic particles will be placed on a diamond cell or pressed into a KBr pellet for analysis. The infrared radiation will be passed through the sample, and the resulting spectrum will be analyzed using specialized software to identify and quantify the micro plastics present in the samples.

FTIR analysis has several advantages over other analytical techniques for identifying and quantifying micro plastics. It is non-destructive, which means that the sample can be analyzed multiple times, allowing for a more accurate assessment of the micro plastic content. It is also highly sensitive, allowing for the detection of even very small concentrations of micro plastics.

The use of FTIR analysis in this study will provide valuable information about the types and concentrations of micro plastics present in the aquatic environment along the Chennai coast. This information will be critical in developing strategies to mitigate the impact of micro plastics on theenvironment and human health.

5 .Results and Discussion:

5.1 Results

The FTIR analysis of water and sediment samples from Chennai's coast identified micro plastics in all samples, such as polyethylene, polypropylene, polyvinyl chloride and polystyrene. The highest concentration was recorded in the industrial zone, ranging from 0.91-1.4 g/mL, while the lowest was in the relative pristine areas.

This is a tabular data set with measurements of various water quality parameters taken at a specific location (longitude and latitude) over the course of a year (2022). The parameters measured include temperature, pH, turbidity, biological oxygen demand (BOD), electrical conductivity (EC), total dissolved solids (TDS), dissolved oxygen (DO), chemical oxygen demand (COD), salinity, and microbial pollution (MP). The measurements were taken at 10 different points at Cooum estuary (C1 to C10) and Adyar Estuary Location (A1 to A10) and within the location, and the values for each parameter at each point are listed in Table 1 and 2 respectively. Figure 6 and 7 shows the pie chart od the collected samples in Adayar and Coovum respectively. Correlation between the parameters are shown in Table 3.

5.2Analysis of samples:

A total of 20 water and 20 sediment samples are collected from the coastal belt of Marina Beach, specifically from the Adyar estuary. The sand samples are obtained by using a 0.5 square meter frame to collect the top 5cm layer. All samples were analyzed for micro plastics within the 0.3mm to 5mm range, and a few samples showed traces of plastics after dry sieving at 90 degrees for 24 hours. Out of the 13 samples collected from Adyar, three had traces of micro plastics, indicating a 60% probability of occurrence. The quantity and characteristics of the plastics are determined using FTIR spectroscopy shows the variation in transmittance values at differentwavenumbers for each sample, indicating the presence and concentration of plastic materials.

5.3 Discussion:

This study found micro plastics in the aquatic environment along the Chennai coast, indicating that their presence is influenced by human activities. Polyethylene, polypropylene, polystyrene and PET particles were identified, with the majority of micro plastics being under 1mm in size. This is of concern, as smaller micro plastics can be ingested by marine life, leading to negative impacts on their health, while larger particles can entangle and block their digestive tracts. To address this issue, measures such as reducing single-use plastic use, improving waste management practices and raising public awareness are needed.

6 Conclusion:

Based on the analysis of FTIR spectra, it can be concluded that micro plastics are present in the aquatic environment along Chennai coast. The presence of various types of plastic polymers such as polyethylene, polypropylene, and polystyrene in the samples collected from the water and sediment indicates that these pollutants are widespread in the ecosystem. The impact of micro plastics on aquatic organisms is a matter of concern as they can be ingested by the marine biota and eventually enter the food chain, leading to potential health risks for humans. The accumulation of micro plastics in the sediments can also alter the physical and chemical properties of the sediment, which can have far-reaching consequences for the overall health of the ecosystem. The results of the research highlighted the importance of proper disposal and recycling of plastics to minimize their impact on the environment and human health. The FTIR technique used in this study provides a valuable tool for identifying the types of plastics present in samples and can aid in the development of strategies to mitigate their negative impact. There are several avenues for future research on the impact of micro plastics in the aquatic environment along Chennai coast. Some potential research directions include:

- Investigating the sources and transport mechanisms of micro plastics in the coastal environment, such as runoff from urban areas, discharge from industrial facilities, and shipping activities.
- Assessing the ecological effects of micro plastics on marine biota, including their impacts on reproduction, growth, and survival.
- Examining the transfer of microplastics up the food chain, from primary producers to higher trophic levels, and evaluating the potential health risks to humans who consume contaminated seafood.
- Developing effective methods for detecting and quantifying microplastics in the environment, including new techniques for sample collection, preparation, and analysis.
- Assessing the effectiveness of current waste management practices and policies in reducing the input of micro plastics into the environment and identifying opportunities for improvement.
- Investigating the potential of natural and engineered remediation strategies for removing micro plastics from the environment, such as the use of biodegradable plastics, bioremediation, and phytoremediation.

Overall, further research on the impact of micro plastics in the aquatic environment is essential to understand the extent and severity of this pollution and to develop effective strategies for mitigating its effects.

REFERENCES:

Ashokan A, R RK, Bharti VS (2023) Anthropogenic litter on sandy beaches in Mumbai Coast, India: a baseline assessment for better management. Arabian Journal of Geosciences 16:73. https://doi.org/10.1007/s12517-022-11155-6

Balachandar K, Viswanathan C, Robin RS, et al (2023) Benthic foraminifera as an environmental proxy for pollutants along the coast of Chennai, India. Chemosphere 310:136824. https://doi.org/https://doi.org/10.1016/j.chemosphere.2022.136824

Cho Y, Shim WJ, Ha SY, et al (2023) Microplastic emission characteristics of stormwater runoff in an urban area: Intra-event variability and influencing factors. Science of The Total Environment 866:161318. https://doi.org/10.1016/J.SCITOTENV.2022.161318

Dhineka K, Sambandam M, Sivadas SK, et al (2021) Characterization and seasonal distribution of microplastics in the nearshore sediments of the south-east coast of India, Bay of Bengal. Front Environ Sci Eng 16:10. https://doi.org/10.1007/s11783-021-1444-0

Goswami P, Selvakumar N, Verma P, et al (2023) Microplastic intrusion into the zooplankton, the base of the marine food chain: Evidence from the Arabian Sea, Indian Ocean. Science of The Total Environment 864:160876. https://doi.org/https://doi.org/10.1016/j.scitotenv.2022.160876

Harikrishnan T, Janardhanam M, Sivakumar P, et al (2023) Microplastic contamination in commercial fish species in southern coastal region of India. Chemosphere 313:137486. https://doi.org/https://doi.org/10.1016/j.chemosphere.2022.137486

Jessieleena AA, Nambi IM (2023) Distribution of microplastics in the catchment region of Pallikaranai marshland, a Ramsar site in Chennai, India. Environmental Pollution 318:120890. https://doi.org/https://doi.org/10.1016/j.envpol.2022.120890

Khuc Q Van, Dang T, Tran M, et al (2023) Household-Level Strategies to Tackle Plastic Waste Pollution in a Transitional Country. Urban Science 7:. https://doi.org/10.3390/urbansci7010020

Mikhailenko A V, Ruban DA (2023) Plastics and Five Heavy Metals from Sea Beaches: A Geographical Synthesis of the Literary Information. J Mar Sci Eng 11:. https://doi.org/10.3390/jmse11030626

Prabawati A, Frimawaty E, Haryanto JT (2023) Strengthening Stakeholder Partnership in Plastics Waste Management Based on Circular Economy Paradigm. Sustainability 15:. https://doi.org/10.3390/su15054278

Pradhap D, Sanjai Gandhi K, Radhakrishnan K, et al (2023) Distribution and characterization of microplastic from reef associated surface sediments of Vembar group of Islands, Gulf of Mannar, India. Total Environment Research Themes 5:100024. https://doi.org/https://doi.org/10.1016/j.totert.2023.100024

Ranjani M, Veerasingam S, Venkatachalapathy R, et al (2022) Seasonal variation, polymer hazard risk and controlling factors of microplastics in beach sediments along the southeast coast of India. Environmental Pollution 305:119315. https://doi.org/https://doi.org/10.1016/j.envpol.2022.119315

Roy P, Pal SC, Chakrabortty R, et al (2023) Effects of climate change and sea-level rise on coastal habitat: Vulnerability assessment, adaptation strategies and policy recommendations. J Environ Manage 330:117187. https://doi.org/https://doi.org/10.1016/j.jenvman.2022.117187

Silori R, Shrivastava V, Mazumder P, et al (2023) Understanding the underestimated: Occurrence, distribution, and interactions of microplastics in the sediment and soil of China, India, and Japan. Environmental Pollution 320:120978. https://doi.org/https://doi.org/10.1016/j.envpol.2022.120978

Sun Y, Li X, Cao N, et al (2022) Biodegradable microplastics enhance soil microbial network complexity and ecological stochasticity. J Hazard Mater 439:129610. https://doi.org/https://doi.org/10.1016/j.jhazmat.2022.129610

Venkatramanan S, Chung SY, Selvam S, et al (2022) Characteristics of microplastics in the beach sediments of Marina tourist beach, Chennai, India. Mar Pollut Bull 176:113409. https://doi.org/https://doi.org/10.1016/j.marpolbul.2022.113409

Yingling Deng Jiang Wu JC, Kang K (2023) Overview of microplastic pollution and its influence on the health of organisms. Journal of Environmental Science and Health, Part A 58:412–422. https://doi.org/10.1080/10934529.2023.2190715

Figures with caption

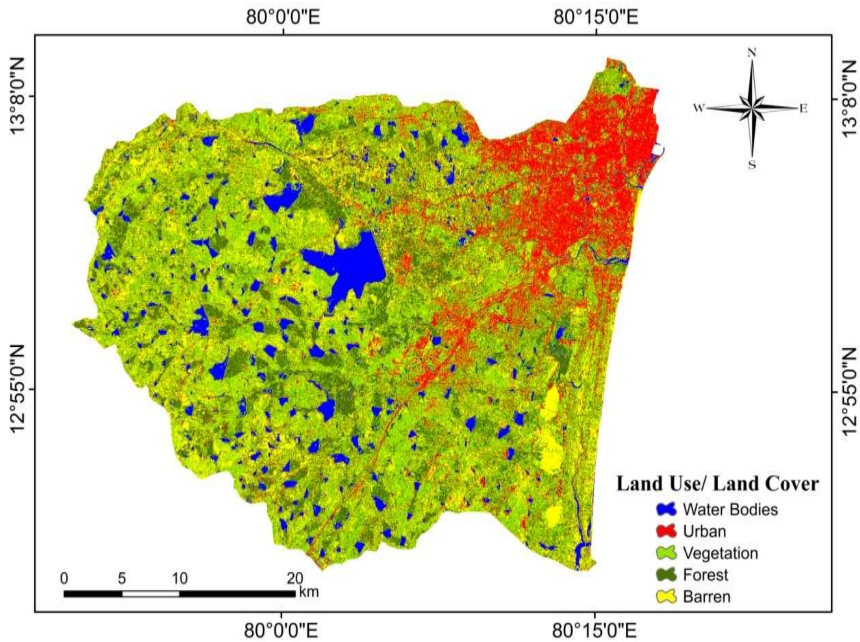

Figure 1

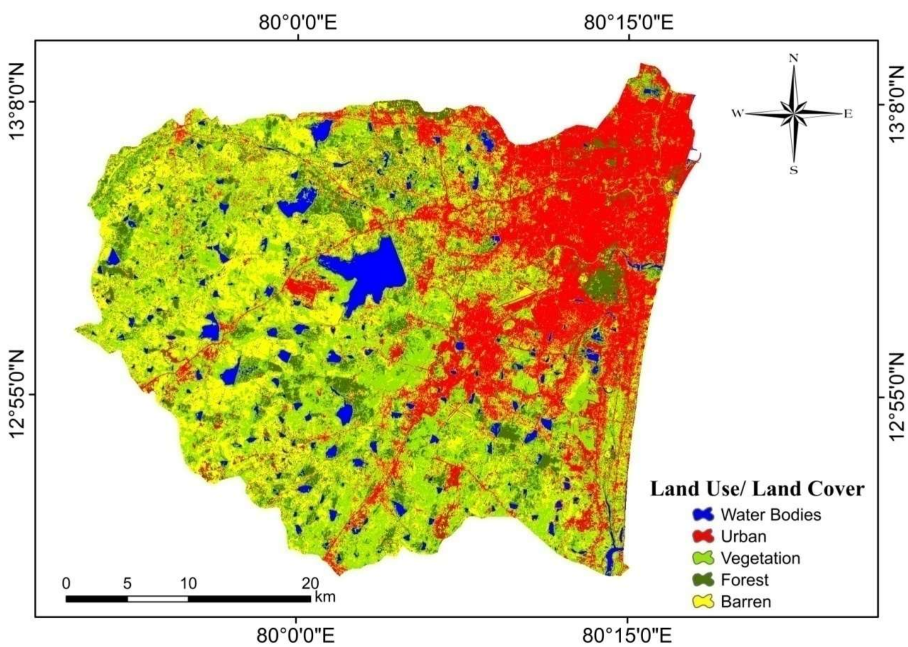

Figure 2

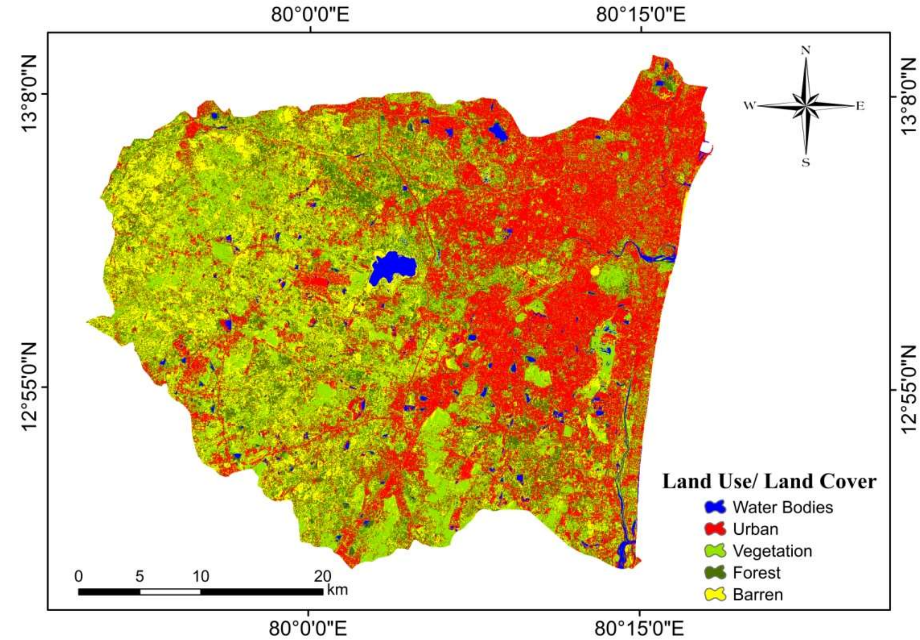

Figure 3

Figure 4 Sediment Sampling

Figure 5 Micro plastic Extractor

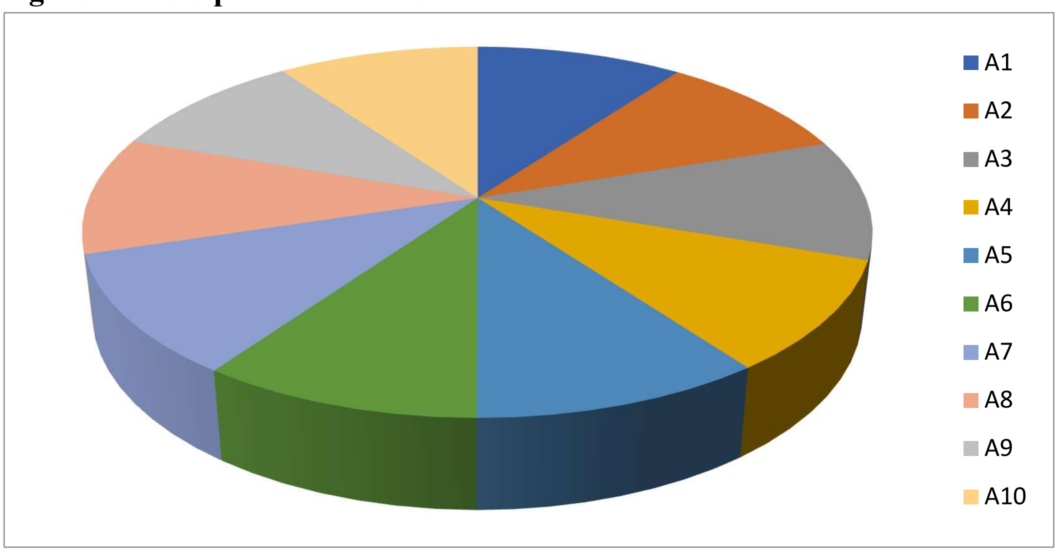

Figure 6 Pie Chart of Adyar Estuary sampling Locations

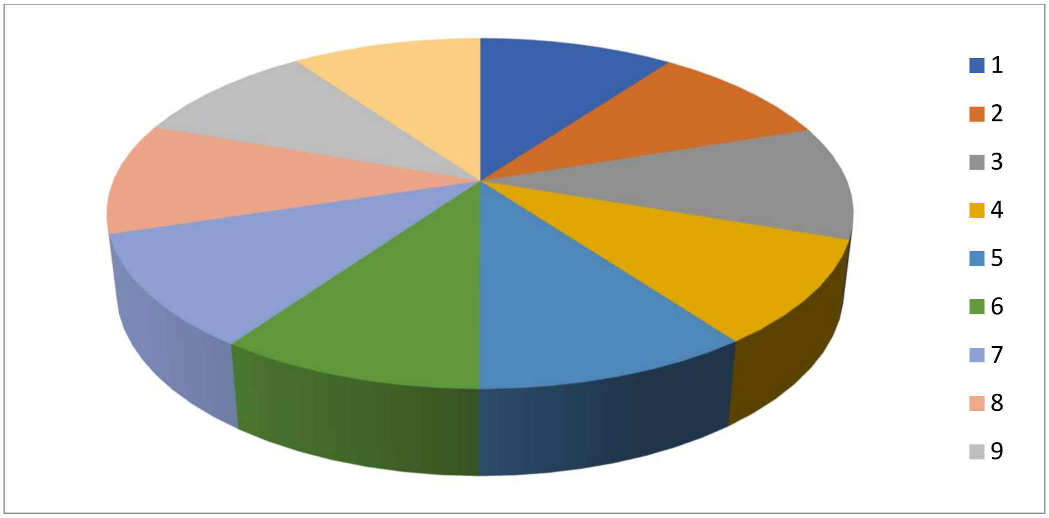

Figure 7 Pie Chart of Coovum Estuary sampling Locations

Table.1: Parametres of Samples from Adyar Estuary

yea r	Sample	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10
	Longitude	80.290 29	80.285 72	80.281 08	80.276 88	80.274 55	80.272 48	80.276 99	80.283 49	80.283 49	80.284 1
	Latitude	13.068 01	13.068 7	13.068 8	13.070 72	13.078 62	13.078 79	13.079 29	13.079	13.074 83	13.070 24
8290 22	Temperature ^{0}C	28.1	27.2	29.2	26.8	28.2	27.1	29.1	28.6	27.1	27.4
	pH	7.29	7.22	7.42	7.0	7.5	7.6	7.8	7.9	7.1	6.3
	EC	28400	29200	31200	34500	30200	30200	35920	31550	33200	32100
	Turbidity(NTU)	14	11	12	17	13	17	18	12	14	12
	TDS(mg/L)	17550	17950	17340	16680	15200	17890	17650	15200	17890	16990
	DO(mg/L)	6.1	6.8	6.3	6.5	7.1	6.5	6.2	7.2	7.3	6.9
	BOD(mg/L)	8	7	7	9	6	7	8	6	7	7
	COD(mg/L)	81	84	80	81	87	88	85	84	87	81
82	80	16.92	17.88	16.68	17.08	17.28	17.88	16.82	17.03	17.91	17.88
	MP(number/L)	250	351	485	720	980	851	590	520	458	398

Table.2: Parametres of Samples from Cooum Estuary

yea r	Sample	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
	Longitude	80.290 29	80.285 72	80.281 08	80.276 88	80.274 55	80.272 48	80.276 99	80.283 49	80.283 49	80.284 1
	Latitude	13.068 01	13.068 7	13.068 8	13.070 72	13.078 62	13.078 79	13.079 29	13.079	13.074 83	13.070 24
8290 22	Temperature ^{0}C	28.1	27.2	29.2	26.8	28.2	27.1	29.1	28.6	27.1	27.4
	pH	7.5	7.4	7.9	7.5	7.5	7.6	7.8	7.7	7.3	7.3

	EC	28400	29200	31200	34500	30200	30200	35920	31550	33200	32100
	Turbidity(NTU)	12	11	12	15	13	16	17	11	13	17
	TDS(mg/L)	17850	17950	16340	16680	17200	17890	17450	17200	15890	16290
	DO(mg/L)	6.0	6.8	6.3	6.2	7.1	7.5	8.2	8.4	7.3	7.1
	BOD(mg/L)	6	7	7	8	7	7	6	7	7	6
	COD(mg/L)	84	84	82	81	87	85	85	84	89	82
82	80	16.22	16.88	18.08	17.08	17.28	18.88	16.82	17.03	17.91	16.88
	MP(number/L)	345	351	455	670	870	851	690	520	455	325

Table 3 Statistical Analysis of sample

Cooum Estuary Location					
	Column 1	*Column 2*	*Column 3*	*Column 4*	*Column 5*
Column 1	1				
Column 2	-0.06039	1			
Column 3	0.134541	0.45828	1		
Column 4	-0.56017	-0.02467	-0.40537	1	
Column 5	0.084888	0.191597	0.578371	-0.3517	1
Adyar Estuary Location					
	Column 1	*Column 2*	*Column 3*	*Column 4*	*Column 5*
Column 1	1				
Column 2	-0.06039	1			
Column 3	0.134541	0.45828	1		
Column 4	-0.56017	-0.02467	-0.40537	1	
Column 5	0.084888	0.191597	0.578371	-0.3517	1
Kovalam Estuary Location					
	Column 1	*Column 2*	*Column 3*	*Column 4*	*Column 5*
Column 1	1				
Column 2	-0.10793	1			
Column 3	-0.10739	0.169838	1		
Column 4	0.697742	0.458242	-0.15681	1	
Column 5	0.387525	0.200522	0.470785	0.405691	1
Ovearall Correlation					
	Column 1	*Column 2*	*Column 3*	*Column 4*	*Column 5*
Column 1	1				
Column 2	-0.13154	1			
Column 3	0.10472	0.014229	1		
Column 4	0.128681	0.223753	-0.23292	1	
Column 5	-0.04936	0.432754	-0.07403	0.167297	1